

- 99 -

Claims:

1. A method of transferring energy from a power source into an output node, said method comprising:
separately charging each of a plurality of energy
5 storage elements from the power source;
after the plurality of energy storage elements are charged, discharging a selected one of said plurality of energy storage elements through an inductive element into the output node; and
10 as the selected energy storage element is being discharged through the inductive element, when its voltage reaches a preselected value, discharging another one of said plurality of energy storage elements through the inductive element into the output node.
- 15 2. The method of claim 1 wherein during the charging step each of the plurality of the energy storage elements is charged to a corresponding voltage, and wherein the method further comprises selecting as the selected energy storage element the one of said plurality
20 of energy storage elements with the largest voltage.
3. The method of claim 1 wherein the output node is at an output voltage and wherein the voltage of the selected energy storage element is at least two times the output voltage.
- 25 4. The method of claim 1 wherein a complete cycle of operation includes the above described charging steps followed by the above-described discharging steps, and wherein said method further comprises causing a complete cycle of operation to occur multiple times per second.
- 30 5. The method of claim 1 further comprising after the plurality of energy storage elements are charged and

- 100 -

before discharging a selected one of said plurality of energy storage elements, inverting the polarity of charge stored in at least some of said plurality of energy storage elements.

- 5 6. A method of transferring energy from a power source into an output node, said method comprising:
from the power source, charging a first energy storage element to a first voltage;
from the power source, charging a second energy
10 storage element to a second voltage;
after the first and second energy storage elements are charged, discharging a first selected one of said first and second energy storage elements through an inductive element into the output node and
15 as the first selected energy storage element is being discharged through the inductive element, when its reaches a preselected value, discharging a second selected one of said first and second energy storage elements through the inductive element into the output
20 node.

7. The method of claim 6 wherein the first voltage is larger than the second voltage and wherein the first selected one of said first and second energy storage elements is the first energy storage element and
25 the second selected one of said first and second energy storage elements is the second energy storage element.

8. The method of claim 6 wherein the output node is at an output voltage and wherein at least one of said first and second voltages is greater than two times the
30 output voltage.

9. The method of claim 6 wherein a complete cycle

- 101 -

of operation includes the steps of first charging and then discharging the first and second energy storage and wherein said method further comprises causing a complete cycle of operation to occur multiple times per second.

5 10. The method of claim 6 wherein the power source is a multiphase line including a first line and a second line and wherein the step of charging the first energy storage element is performed from the first line and wherein the step of charging the second energy
10 storage element is performed from the second line.

11. A sequential discharge circuit for transferring energy from a power source into an output node, said circuit comprising:

15 a plurality of energy storage elements connected to receive energy from the power source;

 a shared inductive element connected between the plurality of energy storage elements and the output node;

20 a plurality of unidirectional switches, each of which when turned on discharges a corresponding different one of said plurality of storage elements through said shared inductive element into the output node, each of said unidirectional switches having a control terminal through which it is turned on; and

25 a control unit connected to the control terminals of the plurality of unidirectional switches and controlling the operation of the plurality of unidirectional switches.

12. The sequential discharge circuit of claim 11 wherein said plurality of energy storage elements
30 includes a first energy storage element and a second energy storage element, wherein the plurality of unidirectional switches includes a first unidirectional

- 102 -

switch connected to the first energy storage element and a second unidirectional switch connected to the second energy storage element, and wherein the control unit is programmed to perform the steps of:

5 charging the first energy storage element from the power source;

 charging a second energy storage element from the power source;

 after the first and second energy storage elements
10 are charged, discharging a selected one of the first and second the energy storage elements through the shared inductive element into the output node; and

 as the selected energy storage element is being
15 discharged through the inductive element, when its voltage reaches a preselected value, discharging the other one of said first and second energy storage elements through the inductive element into the output node.

13. The sequential discharge circuit of claim 11
20 further comprising monitoring the voltage across the selected energy storage element to detect when the voltage of the selected energy storage element reaches said preselected value.

14. The sequential discharge circuit of claim 11
25 wherein the inductive element comprises an inductor.

15. A sequential discharge circuit for transferring energy from a power source into an output node, said circuit comprising:

 a transformer with a primary and a secondary;
30 a plurality of energy storage elements connected to receive energy from the power source;
 a plurality of unidirectional switches, each of which when turned on discharges a corresponding different

- 103 -

one of said plurality of storage elements through the primary of said transformer, each of said unidirectional switches having a control terminal through which it is turned on; and

- 5 a control unit connected to the control terminals of the plurality of unidirectional switches and controlling the operation of the plurality of unidirectional switches.

16. The sequential discharge circuit of claim 15
10 further comprising a shared inductive element connected between the secondary and the output node.

17. The sequential discharge circuit of claim 15
further comprising a shared inductive element connected
between the primary and said plurality of unidirectional
15 switches.

18. A power conversion system for extracting energy from a power source and delivering it to an output node, said system comprising:

a transformer having a primary winding and a
20 secondary winding;
a unidirectional switching device coupled between the power source and the primary winding of the transformer;

a plurality of capacitors connected in series;
25 a charging circuit connected to said plurality of capacitors, said charging circuit charging the plurality of capacitors from the secondary winding of the transformer to a predetermined voltage;

a polarity inverting circuit inverting the
30 polarity of the charge stored in selected capacitors of said plurality of capacitors, said polarity inverting circuit including a plurality of inductor circuits, each of which can be switchably coupled to a corresponding

- 104 -

different one of the selected capacitors to form a resonant circuit which aids in inverting the polarity of a stored charge in that capacitor; and

5 a discharging circuit extracting power from the plurality of capacitors at a transformed voltage.

19. The power conversion system of claim 18 wherein said transformer is a step-up transformer.

20. The power conversion system of claim 18 wherein said transformer is an isolation transformer.

10 21. A power conversion system for extracting energy from a power source and delivering it at a transformed voltage to an output node, said system comprising:

15 a transformer having a primary winding and a secondary winding, said secondary coupled to the output node;

a plurality of capacitors connected in series;
a charging circuit connected to said plurality of capacitors, said charging circuit charging the plurality
20 of capacitors from the power source to a predetermined voltage;

a polarity inverting circuit inverting the polarity of the charge stored in selected capacitors of said plurality of capacitors, said polarity inverting
25 circuit including a plurality of inductor circuits, each of which can be switchably coupled to a corresponding different one of the selected capacitors to form a resonant circuit which aids in inverting the polarity of a stored charge in that capacitor; and

30 a discharging circuit extracting power from the plurality of capacitors and delivering it to the primary of the transformer.

- 105 -

22. The power conversion system of claim 21 further comprising a unidirectional device coupling the secondary winding to the output node.

23. The power conversion system of claim 21
5 wherein said transformer is a step-down transformer.

24. The power conversion system of claim 21 wherein said transformer is an isolation transformer.

25. A system for controlling VAR of a multiphase grid, said system comprising:
10 a plurality of charge storage elements;
a plurality of charge transfer circuits each connected to a corresponding phase of the multiphase grid and to a corresponding one of the plurality of charge storage elements; and
15 a charge redistribution circuit connected to the plurality of charge storage elements, wherein during operation the charge redistribution circuit redistributes charge among the plurality of charge storage devices.

26. The system of claim 25 further comprising a
20 controller which operates the plurality of charge transfer circuits and the charge redistribution circuit, wherein during operation the controller causes the plurality of charge transfer circuits to transfer charge to the plurality of charge storage elements, causes the
25 charge redistribution circuit to redistribute the charge that was transferred to the plurality charge storage elements, and causes the charge transfer circuit to transfer the redistributed charge to the grid.

27. A power flow control system for connecting to
30 a multiphase grid, said system comprising:

- 106 -

a plurality of charge storage elements;
a plurality of charge transfer circuits each
connected to a corresponding phase of the multiphase grid
and to a corresponding one of the plurality of charge
5 storage elements;

a charge redistribution circuit connected to the
plurality of charge storage elements, wherein during
operation the charge redistribution circuit redistributes
charge among the plurality of charge storage devices; and
10 a controller operates the plurality of charge
transfer circuits and the charge redistribution circuit,
wherein said controller controls the power flow into the
system by establishing non-zero initial conditions on the
plurality of charge storage elements prior to a charge
15 transfer cycle during which charge is exchanged between
the grid and the charge storage elements.

28. A derectification system for generating from
a power source a multiphase AC output onto a grid, said
system comprising:

20 a plurality of charge storage elements;
a first charge transfer circuit which charges the
plurality of charge storage elements from the power
source;

a second charge transfer circuit which transfers
25 charge between the plurality of storage elements and the
multiphase grid; and

a controller which operates the first and second
charge transfer circuits, wherein the controller causes
the second transfer circuit to discharge the plurality of
30 charge storage elements onto the grid in order of
increasing voltage, starting with the charge storage
element with the lowest voltage and ending with the
charge storage element with the highest voltage.

- 107 -

29. In a system including a plurality of charge storage elements that are coupled to a power source through a circuit which includes an inductor, a method of generating a multiphase AC output onto a grid, said

5 method comprising the steps of:

sequentially transferring charge between the power source and each of the plurality of charge storage elements so that each of said charge storage elements is characterized by a voltage corresponding to the charge

10 stored therein;

transferring charge between each of said plurality of charge storage elements and a corresponding one of said phases on said grid, wherein the step of sequentially transferring charge is performed in order of
15 increasing voltage on the charge storage elements.

30. In a system which includes a plurality of charge storage elements, a method of controlling power flow between a multiphase grid and said system, said method comprising the steps of:

20 establishing non-zero initial conditions on the plurality of charge storage elements; and

after establishing non-zero initial conditions on the plurality of charge storage elements, transferring charge between the multiphase grid and the plurality of
25 charge storage elements.